U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-256 496

OCCURRENCE AND SIGNIFICANCE OF PESTICIDES IN SOLID WASTES

BUREAU OF SOLID WASTE MANAGEMENT

1970

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-256 496

4. Title and Subtitle
Occurrence and Significance of Pesticides in Solid Wastes.

5. Report Date
1970

6.

7. Author(s)
E. P. Floyd

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Bureau of Solid Waste Management
Cincinnati, Ohio

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

As the production and use of chemical pesticides continue to increase so do pesticide wastes. Many of these wastes are accumulated in the environment and present hazards in many forms. The magnitude of this problem is presented as it relates to solid waste management. Some of the important factors that influence the production of pesticides are listed. Current studies on processing and disposal techniques (composting, incineration, waste management, ultimate disposal, recycling and reuse) for the pesticide wastes and containers are discussed, and new avenues of approach and needed research efforts are suggested for mitigation of the problem.

17. Key Words and Document Analysis. 17a. Descriptors

*Solid waste disposal
*Pesticides
*Environmental impacts
Pollution
Abatement
Supply(Economics)
Chlorine organic compounds
Incinerators
Inventories
Composts
Sanitary landfills
Containers
Management planning
Agricultural wastes

17b. Identifiers/Open-Ended Terms

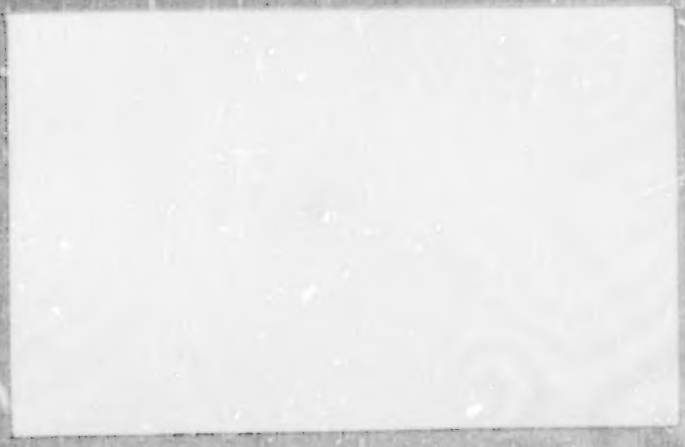
17c. COSATI Field Group 13B, 7C

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
National Technical Information Service Springfield, VA 22161	UNCLASSIFIED	40
	20. Security Class (This Page) UNCLASSIFIED	22. Price PC$4.00/ MF$2.25

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

217843

PB 256 496



RECEIVED
APR 1 1974
LIBRARY
Environmental Protection Agency
CINCINNATI, OHIO

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

OCCURRENCE AND SIGNIFICANCE

OF

P E S T I C I D E S

IN SOLID WASTES

A Division of Research and Development
Open-File Report (RS-02-68-15)
Written by E. P. Floyd, Chemist

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
P U B L I C H E A L T H S E R V I C E
Environmental Health Service
Bureau of Solid Waste Management
1970

TABLE OF CONTENTS

I. INTRODUCTION---------- 1

II. QUANTITIES AND KINDS OF PESTICIDES---------- 5

III. PROCESSING AND DISPOSAL METHODS---------- 8

A. Current Practices---------- 8

B. Grants and Contracts---------- 10

1. Composting---------- 10

2. Incineration---------- 12

3. Waste Management---------- 14

4. Ultimate Disposal---------- 14

5. Recycling and Reuse---------- 18

6. Degradation and Decontamination---------- 22

IV. RESEARCH AND DEVELOPMENT NEEDS---------- 23

A. General Remarks---------- 23

B. Intramural Projects---------- 24

C. Contracts or Grants---------- 25

V. RECOMMENDATIONS AND CONCLUSIONS---------- 27

VI. REFERENCES---------- 28

VII. APPENDIX---------- 31

OCCURRENCE AND SIGNIFICANCE OF PESTICIDES IN SOLID WASTES

ABSTRACT

As the production and use of chemical pesticides continue to increase so do pesticide wastes. Many of these wastes are accumulated in the environment and present hazards in many forms. The magnitude of this problem is presented as it relates to solid waste management. Some of the important factors that influence the production of pesticides are listed. Current studies on processing and and disposal techniques (composting, incineration, waste management, ultimate disposal, recycling and reuse) for the pesticide wastes and containers are discussed, and new avenues of approach and needed research efforts are suggested for mitigation of the problem.

OCCURRENCE AND SIGNIFICANCE OF PESTICIDES IN SOLID WASTES

1. INTRODUCTION

In 1940, the total usage of synthetic organic pesticides in the United States was approximately 280,000 pounds. In 1944, after the discovery of DDT, over 16 million pounds were used, and in 1955 over 475 million pounds were used.[1] Pesticides sales increased 84 percent in the United States from 1955 to 1965. The production in 1965 was 875 million pounds which amounted to $250 million in sales. Population of the United States is now increasing at the rate of 3 million persons each year. Past experience has indicated that we may expect a correspondingly large increase in production of pesticides and resulting increases in pesticide residues throughout the environment and particularly in solid wastes.

Some important factors that contribute toward this increase in pesticide production are: (1) the use of more chemical pesticides to better control the destructive pests that otherwise would seriously curtail farm production; (2) the increasing number of households that will increase the amount of chemical pesticides used for extermination of destructive and nuisance insects, rodents, and plants; (3) use of more chemical insecticides and herbicides in redevelopment areas and in the increasing numbers of industrial sites, airports, highway rights-of-way, etc.; (4) as pests become resistant to chemical pesticides, a tendency to use larger quantities of the currently used pesticides before changing to new kinds; (5) these increasing usages may be further expanded by the national inclination to be wasteful and so use far more chemical pesticides than necessary to do the job.

In preventing pesticides from entering rivers, lakes, and streams, as well as the atmosphere around us, we unintentionally encourage the accumulation of these wastes in the solid form -- the residues from the scrubbing and filtering processes. Ultimately our attention must be directed toward the final means of pesticide disposal in the solid state.[2] Pesticides are spread throughout the environment by many ways, particularly during the application (in many cases 50-75% of the pesticide that is sprayed does not hit the target) and by the persistent residues thereafter, but also by disposal of the waste material[3] -- the unused pesticides, and the bags, barrels, and drums in which they were packaged.

In municipal refuse, a major part of chemical pesticide wastes are found in the discarded pesticide containers, including the spent aerosol cans in which there is always some residue.[3] These are seen commonly in raw refuse at landfill, incinerator, and composting plant sites. The National Agricultural Chemical Association states that "all pesticide chemicals are packed in three general types of containers 1) those containers which are combustible; 2) those containers which are non-combustible but which are small enough in size to be readily crushed or broken; and 3) those containers which are non-combustible and which are not readily crushed or broken."[4]

Included in the combustible category are paper bags, fiber drums, burlap bags, cloth bags, cardboard boxes, fiber boxes, and wooden boxes. The "small non-bombustible" containers include those made of glass, plastic, or metal up to and including the five-gallon size.

The "large non-combustible" containers are defined as 15-, 30-, or 55-gallon metal containers. These large metal containers are generally considered as returnable but will ultimately be discarded.

Fortunately, there are increasing compensatory factors, which, although small, tend to reduce the amount of chemical pesticides used. Some of these factors are: (1) a reluctance to use pesticides due to past experience with misuse of them that resulted in the mass killing of fish, birds, and mammals; (2) lower tolerance levels in foods as established by the Food and Drug Administration; (3) development and use of methods for controlling pests other than by chemical pesticides.

Recently, the public has become quite concerned about the spread of pesticides around the world (due mostly to the extensive use of DDT and its persistence).[5,6,7,8,9] Hardly a day goes by when there isn't an account in the news media about new attempts to ban or regulate the use of certain persistant pesticides. Already there are laws restricting certain usages of DDT in Michigan, Wisconsin, Arizona, and Sweden. Legislation is pending now in 18 of the 50 United States to ban the use of DDT.[10] Sudden banning of the use of pesticides leaves the manufacturer, distributor, and merchant with quantities of pesticide which cannot be sold. These once marketable materials then become waste, and are suddenly a liability instead of an asset.

The Bureau of Solid Waste Management is concerned about the presence of pesticide residues in solid wastes because of: (1) possible occupational hazards caused by direct contact or by dust to sanitation or public works employees or to others; (2) threats to

the normal biota of the environment (fish, wildlife, agricultural crops, domestic animals, etc.); (3) possible adverse effects on microbiological processes occurring within composting material or sanitary landfills; (4) possible adverse effects on the utilization of solid wastes--cannery wastes, for example, are no longer fed to milk cows because of the restrictions on pesticide levels in milk; (5) possible contamination of the environment through leaching by groundwater or surface water, winds, evaporation, and stack emissions of incinerators; for example, one of the combustion products of chlorinated hydrocarbons is hydrogen chloride, which is toxic and corrosive.

The knowledge of combustion efficiency of these wastes in conventional incinerators is not sufficient to assure that the environment is being adequately protected. The placing of pesticide wastes in sanitary landfills raises the question of movement of these wastes into groundwater. Although the persistence of pesticide residues in composted agricultural wastes is under study by the Bureau of Solid Waste Management, composting does not seem to be a feasible means for disposing of pesticide wastes or waste containers, per se.

II. QUANTITIES AND KINDS OF PESTICIDES

In 1965, U.S. pesticides sales were divided into 38% for agricultural, 25% for institutional, 12% for residential use, and 25% for export. To emphasize the agricultural involvement with pesticides, Neumeyer, et al. stated that "crops are grown in an environment in which they must compete with 50,000 species of fungi that cause more than 1,500 plant diseases, with 30,000 species of weeds (more than 1,800 of which cause serious economic losses), with 15,000 species of nematodes (1,500 of which damaged important crops), and with more than 10,000 species of pest insects."[11] They also predict that total pesticides sales will top $3 billion by 1975.

Currently, there are approximately 390 chemicals used to control weeds, insects, nematodes, rodents and plant diseases.

Herbicides have played a major role in the pesticides boom[12,13]--with production value increases in excess of 20% per year.

According to a U.S. Department of Agriculture survey of consumption in 1964 (the most recent year for which complete figures are available), U.S. farmers used about 458 million lbs. of technical pesticide chemicals.[11] Of these, 37% were fungicides (mostly inorganics), 34% insecticides (mostly organics), and 29% rodenticides, fumigants and defoliants. Among the herbicides, 2,4-D accounted for 40% of the organics while triazines accounted for 15%.

For insecticides in 1964, chlorinated hydrocarbons made up 65% of the total used;organic phosphates added 22%; carbaryl (Sevin®), a carbamate, accounted for about 11% while all other types amounted to only 1%. Sulfur, either elemental or combined, made up more than 80% of all fungicides used. Other inorganics, including copper and zinc compounds, added approximately 5%. Among the organics, the dithiocarbamates accounted for approximately 8% of the total fungicides; Captan,® dichlone, and dcdine were the other major products (7%).

Fo the miscellaneous category (rodenticides, fumigants, and defoliants) half was made up of D-D® (a combination of 1,2 dichloropropene and 1,3 dichloropropene). Defoliants and desiccants (mostly inorganics) were second in importance in this group, while miticides made up less than 10% of this miscellaneous group.

According to Neumeyer, et al.[11] the most dominant pesticides based on sales are as follows:

$25 million and over	$10-25 million	$5 -10 million
Atrazine	Aldrin	2,4,5-T®
Treflan®	Ramrod, Randox and Related products	Tordon®
Sevin®		Methyl bromide
Amiben® and Related products	Diazinon®	Knoxweed® (EPTC, 2,4-D)
Malathion	toxaphene	Disyston
2,4-D	DDT	Thimet®
	Methyl parathion	Pentachlorophenol
	Parathion	Methyoxychlor
	Guthion®	Kelthane®
	Planavin	Bux-Ten®
	Endrin	Cyprex®
	Dithiocarbamates	Paraquat
	Captan	Banvel®
	Chlordane	
	Heptachlor	

In order to determine what pesticides might be found in solid wastes some knowledge of the production or sales is necessary. With this in mind a small survey was made in Johnson City, Tennessee in conjunction with the Joint PHS-TVA Composting Project, Johnson City, Tennessee, to find out what kinds of pesticides were available locally which might contribute to the municipal refuse going to the Johnson City Composting Plant. In this short study five local supermarkets were visited and the kinds of insecticides stocked by them recorded. The following pertinent information was obtained:

(1) forty-three different brand name insecticides were found in stock;

(2) of these there were 25 aerosols, 12 liquids, 5 powders, and 1 strip;

(3) the store managers knew very little about the pesticides, except that they were seasonal items;

(4) most common active chemicals noted were pyrethrins, piperonyl butoxides, DDVP, dieldrin, DDT, chlordane, carbaryl, Diazinon®, rotenone, sodium arsenite, and boric acid.

Johnson City has "insect-vector" control by which spraying teams follow the collection trucks and spray each empty garbage can with 4% malathion. This is done twice during the summer. On these occasions some of the malathion must certainly get into the solid waste. At the composting plant itself the windrow fields are fogged with dimethoate, introducing another pesticide to the compost.

Note: Agricultural wastes are not accepted at the Johnson City Composting Plant.

III. PROCESSING AND DISPOSAL METHODS

A. Current Practices

The conventional disposal techniques for solid pesticide residues are two basic processes : (1) to detoxify the waste pesticide by degradation or decomposition; (2) to concentrate and contain the toxic material in a safe location. The latter merely postpones the ultimate disposal problem unless degradation occurs during the containment. The most desirable disposal technique involves rapid decomposition and dilution of the end products.

One company has announced a process for "pollution control at a profit whereby chlorinated hydrocarbon wastes are converted into anhydrous HCL -- a money-making solution to a difficult disposal problem."[14] Current techniques considered practical for pesticide processing and disposal are as follows: (1) rapid decomposition by use of heat as in incinerators or pyrolizers; (2) chemical treatment such as that with caustic soda or mineral acids; (3) natural decomposition aided by soil microorganisms, air and sunlight; (4) burial in controlled sites using steel drums; (5) pumping into deep wells that store the wastes below, and isolated from, usable groundwater.

Each of these techniques has associated problems. First, the limiting efficiencies of the treatments allow contamination of the environment with some of the unaltered toxic pesticides. Second, the end products following treatment almost always require disposal or utilization.

According to the Midwest Research Institute report on packaging the relative dominance (by weight) of disposal methods in 1966 in the United States was 14.0% by incineration, 5.0% by sanitary landfill, 77.5% by open dumping, 0.5% by composting, and 3.0% by salvage.[15] Waste pesticides are included in all of these, but not in the same proportions. Process and packaging wastes are important components of solid pesticide wastes.

The greatest amount of pesticide wastes generated (outside the manufacturer's pesticide process wastes) is in agricultural areas. In agricultural areas landfills are more numerous than incinerators, and frequently the landfill is actually an open burning dump; therefore, at least at the present, more of the pesticide wastes are transported to landfills than to incinerators. Unfortunately, most of the unused pesticide wastes and containers are not taken away at all. The discarded pesticide bags are usually piled in a corner of the field and burned. The waste plant stems, leaves, roots, etc. which are not marketable, and which commonly contain pesticide residues, are generally plowed under.

The National Agricultural Chemicals Association recommends specific disposal methods in its "Manual for Decontamination and Disposal of Empty Pesticide Containers" (1965).[4] Excerpts from this are given in Appendix A. Also in the NACA manual specific directions are given for decontamination of the containers for reuse. Similar recommendations for the proper disposal of waste pesticides and containers are given by the American Public Health Association[16] and the U.S. Department of Agriculture.[17,18]

B. Grants and Contracts for Determining Proper Ways for Processing and Disposing of Pesticide Wastes

The program of the Bureau of Solid Waste Management in relation to solid pesticide waste disposal is part of a broad effort to upgrade solid waste management. The Bureau is sponsoring, through the grant and contract processes, efforts to upgrade the management of pesticide and toxic or hard-to-handle wastes through improvements in processing and disposal practices which will minimize environmental pollution and enhance the efficiency of the processing system. Studies bearing on disposal of pesticide containers, and the effects of pesticides on various solid waste processes (such as composting) are clearly within the responsibility of the Bureau of Solid Waste Management. There are other interested and actively participating agencies, for example, the USDA,[12,19,20,21] USDI, FDA,[19] the Office of Pesticides, and Resources for the Future.[13]

1. Composting

Composting of municipal and agricultural refuse is not widely used as a means for solid waste disposal in the United States. However, there are several compost plants in operation, and one may reasonably expect to see continued composting of solid waste on a limited scale in areas where the product is marketable.

A research grant, (UI-00553) funded by the Bureau of Solid Waste Management, to the Western Research Laboratory of the National Canners Association, Berkeley, California, is supporting a study of the fate of insecticides in composted agricultural wastes.

A substantial part of the fruits and vegetables received for preservation by canning or freezing is discarded as solid wastes. That portion of the raw product which is discarded -- vegetable skin and rind -- generally has the highest level of insecticide residue, and this fact has limited the use of such material as animal feed, and also raises questions about possible harmful effects of spreading composted cannery wastes on agricultural lands. This concern is especially justified if toxic degradation or transformation products remain in the compost mixture.

The National Canners Association study aims to obtain a better understanding of the mechanism by which insecticides are degraded by microbial or chemical action, and also to obtain information which will make it possible to dispose of waste materials containing concentrated insecticide residues without hazard to public health. Insecticides selected for the study represent examples of the three principal classes: chlorinated hydrocarbons, organophosphates, and carbamates. The selection of specific insecticides was based upon the extent of usage in agricultural products, variety of chemical structure, and availability of reliable analytical methods. These included: dieldrin, parathion, Diazinon®, DDT, carbaryl (Sevin®), and zineb.

Batch and continuous bin compost experiments were initiated with cannery wastes and rice hulls treated with insecticides. Fresh waste was again added to the batch type experiments after the original waste had gone through a complete compost cycle. Fresh waste was added to the continuous thermophilic bins 3 times a week to maintain high temperatures. Active composting proceeded

for 4 months, followed by 6 months of curing. The data indicated a rapid decline in the concentration of Diazinon® and parathion by either compost method. Thermophilic composting reduced the concentration of the insecticides faster than batch-type composting. Dieldrin was degraded faster in the batch process than in the thermophilic experiment. Aldrin, an expected conversion product from dieldrin, was not detected. DDT was not significantly degraded by either compost method. DDE, a normal conversion product, was not detected. Following the active compost period (120 days) the curing or aging phase of the compost process had little or no effect on the insecticide (dieldrin, p,p'-DDT, parathion, Diazinon®).

While the study is still incomplete, the break down products of several insecticides have been identified and the varying effects of batch-type and thermophilic composting processes have been noted.

2. Incineration.

Incineration is a solid waste reduction technique which has received fairly wide application, both by municipalities and in certain institutions, such as hospitals. The incineration of special wastes poses potential health hazards from the standpoint of air pollution and the quality of ash and residue which must ultimately be deposited on the land, preferably in a sanitary landfill.

At Mississippi State University a team of scientists working under a grant[22] from the U.S. Department of Agriculture on pesticide disposal in which twenty selected pesticides were analyzed have concluded that incineration is better than chemical methods for the destruction of waste pesticides. However, by-products of incineration such as ashes have to be disposed by some other method, possibly burial. Results of the investigation further indicated that combustion temperatures of the pesticides being investigated were well within the range of feasible temperatures obtainable with conventional incinerators; but of the 15 different types of incinerators surveyed, only one provided for efficient entrainment of gaseous and solid residues.

By use of differential thermal analysis (DTA) several different pesticides were tested separately in atmospheres of nitrogen, air, and oxygen for temperatures increasing to 1000°C. This end temperature was found to be sufficient to degrade 99% or more of most commercial pesticide formulations. The scientists working on this grant suggested that burning pesticides in an open flame, as in a backyard incinerator where paper or other wastes are the only fuel, may result in toxic gases. They also concluded that longer combustion at lower temperatures may produce quite different end products (possibly less toxic) than faster combustion at higher temperatures.

A contract (CPE 69-140) has just recently (June, 1969) been awarded to Foster D. Snell, Inc. of New York City to investigate the necessary conditions for proper decontamination and combustion of organic pesticides by investigating (1) selected oxidizers and combustible binding agents, and (2) combustion characteristics and requirements for container composition.

Each mixture of pesticide and selected combustion aid is to be investigated to determine the temperature and rate at which it burns. Combustion gases from this procedure will be examined for degree of conversion to carbon monoxide, carbon dioxide, water and intermediate organics. Also, binding agents will be applied to such mixtures prior to combustion to test for prevention of mechanical entrainment of the pesticide in the flame convection currents.

Combustion temperatures and characteristics, including completeness of consumption, for common container types will be determined. Based on these studies, requirements for combustible pesticide containers will be developed. Work performed under this contract will be coordinated with and augmented by that performed at Mississippi State University (described above) and Oregon State University (described below).

3. Waste Management.

The Environmental Health Sciences Center of Oregon State University has been awarded a three-year demonstration grant (beginning July 1, 1969) (G06-EC-00222) to study "Waste Pesticide Management." The principal objectives of this project will be to develop technical information and a management system for reduction of pesticide waste problems. Their studies will be on utilizing the potential of the soil for biological and physical degradation of chemical pesticides. In addition, they will investigate the problem of decontamination and re-use or disposal of pesticide containers.

4. Ultimate Disposal.

The sanitary landfill is regarded by the Bureau of Solid Waste Management as an important land disposal method, and consequently a considerable research and development effort is directed toward improving this

technique, and assuring its safety from the pollution standpoint. If properly located and engineered, one of the most favorable qualities of the sanitary landfill is its ability to receive a heterogeneous solid waste load from relatively innocuous and chemically inert plastics and aluminum, to putrescible and even toxic materials.

For every sanitary landfill, and particularly those receiving such toxic materials as pesticide residues, it is important to assure that there is no contamination of nearby ground and surface waters. The Bureau of Solid Waste Management is sponsoring a demonstration grant (G06-EC-00006) for staff members of the Illinois State Geological Survey and the Department of Geology, University of Illinois, to study the hydrogeology of several solid waste disposal sites. Data from the study will be useful in evaluating the factors that control groundwater and landfill leachate movement. Five different hydrogeologic environments were selected for the study and piezometers were installed in drill holes, strategically located to define fluid potential distribution, and water samples are being taken for chemical analysis.

The U.S. Geological Survey, Water Resources Division performed a study for the Federal Water Pollution Control Administration on "Potential Contamination of the Hydrologic Environment from the Pesticide Waste Dump in Hardeman County, Tennessee"[23] in which they found that "the shallow burial of pesticide wastes in Hardeman County has contaminated portions of both the surface and subsurface environment at the disposal site. Evidence of contamination of the surface environment was found in samples of the surface soil at the disposal site, in samples of sediment washoff from the disposal site, and in samples of the bedload in Pugh Creek as far as 1-1/2 miles downstream from the site.

On the other hand, the water portion of samples from Pugh Creek did not contain any detectable amounts of chlorinated hydrocarbons.

"In the subsurface the buried wastes have produced a zone or enclave of contamination directly beneath and peripheral to the disposal pits. Laterally, the limits of the enclave appear to be confined within a distance of 25 feet from the outermost margins of the disposal pits. The depths of the enclave, however, extends nearly to the water table which is about 90 feet beneath the land surface.

"The vertical movement of the pesticide contaminants from the disposal pits poses a contamination hazard for 2 of the 3 groundwater bodies that occur beneath the disposal pits. The shallowest groundwater body (a perched water zone) has already become contaminated as evidenced by analytical results of water samples from shallow wells marginal to the disposal pits. In addition to the perched water zone, a substantial portion of the local water-table aquifer, the principal source of local domestic water supplies, is exposed to the hazard of contamination from the pesticide waste disposal pits.

"The contaminants that are entrained in the flow systems of the perched water zone and the water-table aquifer will move laterally toward the discharging boundaries of these groundwater bodies. The contaminants entrained in the perched water zone will move toward the discharging boundaries that are located within the surface ravines draining the disposal pits. The maximum rate of movement in the zone under prevailing hydraulic gradients is calculated to be about 2 feet

per day. Hence, the entrained contaminants could reappear at the land surface in as little as 100 or as many as 1200 days after entry into the perched zone.

"The contaminants appear to have a greater affinity for clayey earth materials than for water. It is, therefore, doubtful that the contaminants will move as rapidly in the subsurface as groundwater is able to move. It is also unlikely that contaminated particles of sediment in the draws and in Pugh Creek will be relieved of contaminants merely by association with water.

"Certain features of the environment of the disposal site serve to delay the contamination hazard to the hydrologic system. These are:

a) the 90-foot depth to the water table;

b) the presence of 3 beds of lowly permeable clayey material in the zone of aeration;

c) the prevailing easterly water table gradient;

d) the remoteness of the disposal site from local inhabitants."

Oceanic disposal of solid wastes, including pesticides and other toxic materials, may be an alternative to the sanitary landfill method. A contract (PH86-68-203) has been let to the Applied Oceanography Branch of the Dillingham Corporation, San Diego, California, for the purpose of determining the nature and magnitude of present ocean disposal practices. The Dillingham study also seeks to determine what present or potential effects known ocean disposal activities may have on public health or esthetics. In connection with the study, on-site

surveys are being conducted in 16 U. S. cities situated on or near the Atlantic and Pacific coasts, and the Gulf of Mexico.

Deep wells are also a possibility, although generally frowned upon because of the possibility of groundwater contamination through faulting of the earth.[24,25]

Studies by the U.S. Geological Survey in cooperation with Colorado School of Mines, Regis College, and the University of Colorado showed a definite relationship between the incidence of earthquake activity since the spring of 1962 and the dumping of waste fluids down a 12,000 foot deep disposal well at the Rocky Mountain Arsenal located at Commerce City near Denver.[26] If large amounts of pesticide wastes were disposed of in this manner the potential would always exist that contamination of groundwater could occur. In spite of the potential hazards their use still continues. At Chemetron's pigment plant in Holland, Michigan, and at Hooker's Niagara Falls, New York plant deep wells will hold hard-to-treat wastes for "permanent" disposal. The indication is that after much optimism and some difficulties this disposal method is being accepted by chemical plants.[27]

5. Recycling and Reuse.

The concept of solid waste management extends beyond disposal, to include recycling and reuse of waste materials, whenever and wherever possible. Some of the present barriers to increased waste utilization are technological and others are economic. Overcoming

these barriers is an important goal of the Bureau, because success in increasing the amount of waste that can be reused has the dual advantage of reducing the amount which must be disposed of, while conserving the nation's natural resources.

Cellulosic wastes, including wood, bark, sawdust, oat hulls, corn cobs, bagasse and other agricultural residues are generated in truly prodigious quantities. Little, if any significant portion of these wastes is beneficially used, and, since they are commonly burned, cellulosic wastes often contribute to air pollution in areas where they accumulate. The Bureau of Solid Waste Management has recently awarded a research grant (RO1-EC-00319) to the Institute of Forest Products, University of Washington, in Seattle, for the purpose of developing a unique means for utilizing cellulosic wastes which will at the same time allow safer and more efficient application of pesticides to the soil.

Some common properties of the wood wastes mentioned are: that they consist predominantly of polymeric cellulose macromolecules; they contain an abundance of replaceable hydrogen atoms; and all are biodegradable. Since these waste materials are polymers containing replaceable hydrogen atoms, it should be possible to attach pesticides to these substrates in the same way that acetic acid, for example, becomes attached to cellulose in the manufacture of cellulose acetate. Although this study has just begun, earlier research has shown that pesiticdes can be attached to such solid waste as sawdust, bark, and lignin by means of ester linkages.

The practical implication for the ability to chemically bond pesticides to cellulosic materials is that very large quantities of cellulosic wastes, so treated, could be utilized as a mulch for gardens and in agriculture. The pesticide in the mulch would be released in controlled fashion with distinct advantages over present procedures for applying pesticides to soils. Now, pesticides usually have rather short useful lives because they may be degraded by bacteria to inactive metabolites, or washed by rainwater into the subsoil where they are inaccessible to pests they are intended to control. Also, and more important from the public health standpoint, this leaching into the subsoil often means that some rather stable pesticides, or their degradation products, find their way into potable water supplies.

In contrast, if the pesticide were chemically combined with the polymeric solid waste by displacement of a replaceable hydrogen atom then its useful life should be prolonged; attack by bacteria should be reduced; and the pesticide should not be leachable into the subsoil and hence will not pollute groundwater. As the solid waste-pesticide mulch lies on and in the soil it will gradually decompose, continually releasing the active pesticide over a long period of time. With this technique the problems and potential errors of measuring and diluting liquid concentrates are eliminated. Spillages of solids are, of course, less likely than liquid leakages and are easier to rectify when they occur. Controlled releases of the pesticides may also allow lower dosage and fewer applications for the same desired effect.

Another very important implication for this project is the prospect it may hold for development and use of extremely short-lived biodegradable pesticides which, in combination with solid waste polymeric substrates, would be sufficiently stable for practical use. For example, many organophosphorus pesticides, such as octamethylpyrophosphoramide, are liquid and are too dermally toxic to permit their use by other than experts. Chemical combinations of these materials would render them safe, while not destroying their biological activity. The currently "unusable" pesticides are often effective at much lower dosages than the superficially less hazardous products that are now used in relatively massive amounts.

Union Carbide's Materials Systems Division has gone beyond the experimental stage for recycling of materials and now have developed an incinerator-scrubber system[14] which represents the newest attack on a pressing problem: disposing of the 1 billion lbs of waste generated each year in the U.S. in the production of 12 billion lbs of chlorinated organics. Union Carbide's incineration-scrubbing system is designed to recover 99% of the hydrogen chloride formed in the incinerator as 18-degree Baume acid. Alternatively, Union Carbide offers a unit with a stripping system to convert the product acid into anhydrous hydrogen chloride. In either case, according to Union Carbide the venting gas stream will confrom to most state regulations; and with additional scrubbing stations, its HCl content can be slashed from 1,000 ppm down to 50 ppm.

Union Carbide estimates the installation costs at about $500,000 for each ton/hour of waste processing capacity. Operating costs are estimated at $18/hour, which would put waste disposal costs at about 10¢/gal. This is the upper limit of the 5-10¢/gal range of conventional disposal costs. But with the new system, the operator has a by-product to sell and he can meet antipollution requirements.

6. Degradation and Decontamination.

Efforts to degrade or decontaminate waste pesticides have been numerous but only two will be mentioned here. The U.S. Department of Agriculture grant at Mississippi State University referred to earlier includes studies along this line. These scientists are determining the effects of pesticides on the soil microfauna in regard to whether they may have a toxic effect on the fauna or that the fauna may metabolize the pesticide. In the latter case addition of nitrogenous and carboniferous materials to the soil may serve as a fuel for this process just as gas or oil may serve as a fuel for incineration. Some of their findings were that strong mineral acids were more efficient chemical agents than alkalies for degradation of pesticide molecules. Some pesticides were found to resist microbial decomposition and also inhibited the breakdown of some organic matter.

The goal of a study contract let by the Federal Water Pollution Control Administration to Aerojet Corporation is to produce a catalyst that would cause DDT to destroy itself.[28] The firm received $96, 520 to try to develop a catalyst that will force DDT to decompose--or at least begin the process--two to four weeks after application. It now takes 10 to 12 years for DDT to break down. Research will be conducted at Aerojet-General laboratories at El Monte, California.

IV. RESEARCH AND DEVELOPMENT NEEDS

A. General Remarks

The Utopian method for disposal of large quantities of waste pesticide is by conversion into useful products. This has proven possible in only a few instances. In municipal wastes, the pesticides simply go along with the mass of material into the incinerator, the sanitary landfill, or the composting plant. When ways are found to separate the pesticides from the other wastes, they can be treated specially, as they are (or should be) at the pesticide manufacturing plant.

Pretreatment of pesticide wastes as a possible aid in disposal should be considered for the future. Some of the possibilities include the removal of some of the organic materials by absorption before incineration, treatment by radiation in a pebble bed reactor, or oxidation and photochemical reactions before incineration.

Special attention must be given to the design of the container itself in both its physical and chemical characteristics. A more durable container may be more readily decontaminated. The behavior of the container as well as its contents and their interaction during storage must be considered especially in searching for a more combustible container material. Incineration by itself cannot be considered a complete disposal system since some type of pretreatment may well be necessary and in most cases the residue and toxic gases in the effluent will have to be collected and disposed of in some other way. Microbial decomposition may play a role in the disposal of the residue. Partial incineration at

a lower temperature may result in a product that can be more readily decomposed chemically or biologically. There is little hope for low cost incineration of pesticides containing mercury, arsenic, and other elements that are toxic in themselves. An alternate method in this case is indicated.

Efforts should be applied toward reducing the amounts of pesticide wastes, enhancing the design and use of containers, including mandatory use of returnable ones and in general keeping the consumer better informed about the proper use and disposal of pesticides and their containers.

B. Intramural Projects

1. Determine the amounts and kinds of pesticide residues in refuse before and after processing (incineration, composting, pyrolysis, etc.) by use of screening tests in which all the major pesticides of the area served are tested for. Determine the breakdown products of each pesticide found in the refuse. Based on these data define the severity of the problem and begin planning for mitigation of the problem. This problem should involve two professionals for a period of three years with a preliminary report at the end of the first year indicating all the analytical techniques and the results of the screening tests, a report at the end of the second year on the breakdown products of pesticides found, and a final report at the end of the third year on all the activities performed including recommendations for alleviation of the problem.

2. Determine the toxicity and potential hazard of each pesticide found in refuse through literature search and correspondence with other agencies involved in pesticide studies. This project should require no more than one man-year, but must follow the findings of the screening tests. Reports should be prepared as soon as possible for each pesticide found in potentially hazardous amount, and should indicate the type of hazard most likely to occur -- occupational, accidental, or unwanted alteration of the ecological system.

C. Contracts or Grants

1. Assess the effects of present incineration practices on the integrity of the pesticide molecule. For example, in the presence of heat carbon tetrachloride may be partially converted into phosgene, and it is already established that chlorinated hydrocarbons (like PVC) produce hydrogen chloride when incinerated causing corrosion of the metal parts of the incinerator. This project should require two years at approximately $50,000 per year.

2. Assess the effects of the new and more advanced incineration techniques on pesticide wastes and containers. Project activities should supplement work now being done by Foster Snell Co. and Oregon State University. Activities should be on-site at existing incinerators regardless of their locations. Much of this could be incorporated in already active contracts with additional funding and perhaps some time extension.

3. Develop a satisfactory means for cleaning and salvaging pesticide containers. Coordinate activities with existing contracts such as that with Oregon State University on "Waste Pesticide Management." This project should require approximately two man-years. An early preliminary report should indicate current practices and research efforts. A report at end of project should give recommendations on cleaning and salvage of pesticide containers.

4. Develop the necessary incentives to encourage the producers and distributors of hazardous materials and/or containers to accept responsibility for the waste disposal or reclamation associated with these materials. Project should require one professional approximately one year at a cost of $30,000.

5. Develop analytical methods for pesticides most commonly found in solid wastes including sampling techniques (for the extremely heterogeneous solid waste material) sample preparation, and definitive analysis. Techniques should be developed for rapid screening tests for identification, and also for precise and accurate measurement of each pesticide. This work must be performed by a top-quality laboratory equipped with gas chromatographs, and solvent extraction equipment and operated by experienced analysts. Two professional chemists working in an already equipped laboratory should be able to develop analytical methods for six pesticides in one year at a cost of approximately $50,000.

V. RECOMMENDATIONS AND CONCLUSIONS

Since 1944, following the discovery of DDT, the use of chemical pesticides have increased greatly. It has been predicted that sales of pesticides will top $3 billion by 1975. About 390 chemicals are currently in use to control weeds, insects, nematodes, rodents, and plant diseases. Much of the pesticide material contaminates the environment through inefficient application and improper disposal. Some of the pesticide residues are stable enough that they remain in the environment for many years and in some cases are concentrated and accumulated in plant and animal tissues. The public has become aroused by this accumulation and persistence of some pesticides, notably DDT, so that now there are efforts in several states to ban (by law) the sale and use of certain pesticides.

The extent of this problem must be determined for solid wastes management--collection, transport, processing, and ultimate disposal and the potential hazard by occupational exposure, accidental exposure, or effect on the eco-system including the breakdown products of the pesticide following treatment, or degradation. When the significance of the presence of pesticides in solid waste is well-defined then proper methods for decontamination must be developed for problem quantities of pesticides, better methods for processing and disposal must be found, and incentives must be developed for reducing the source of pesticide wastes.

VI. REFERENCES

1. Rosen, A. A. and H. F. Kraybill. Organic Pesticides in the Environment. Advances in Chemistry Series 60. American Chemical Society, Washington, D.C., 1966.

2. Breidenbach, A. W. Editorial. Pesticides Monitoring Journal, 2(2),71, September 1968.

3. Wolfe, H. R., et al. Health Hazards of Discarded Pesticide Containers. Archives of Environmental Health, 3(11):45-51, November 1961.

4. Manual for Decontamination and Disposal of Empty Pesticide Containers. National Agricultural Chemicals Association. Washington, D.C., June 1965.

5. Laycock, G. The Beginning of the End for DDT. Audubon Magazine, 71(4), July 1969.

6. Anonymous. Environmental Pollution is Caused by Major Flaws in our Technology. Chemical and Engineering News, 47(19):27, May 4, 1969.

7. Anonymous. Pesticide Concern in the U.S. New Scientist, 42(646):169, 1969.

8. Anonymous. Pesticides Dominate Chemical News at Both Federal and State Level Last Week. Chemical & Engineering News, 47(19):27, May 4, 1969.

9. Wood, D.L., R. M. Silverstein and Mr. Nakajima. Meetings: Pest Control. Science, 164(3876): 203-10, April 11, 1969.

10. Anonymous. Citizen Groups Press for Legislation to Ban Use of DDT. Chemical & Engineering News, 47(20):28-9, May 11, 1969.

11. Neumeyer, J., D. Gibbons and H. Trask. Pesticides. Chemical Week, 104(15&17):37-68, April 12 & 26, 1969.

12. Mahan, J. N., D. L. Fowler and H. H. Shepard. The Pesticide Review, 1968. USDA Agricultural Stabilization and Conservation Service, Washington, D. C., December 1968.

13. Headley, J. C. and J. N. Lewis. The Pesticide Problem: An Economic Approach to Public Policy. Resources for the Future, Inc., Washington, D. C., 1967.

14. Anonymous. Solving Waste Problem Profitably. Chemical Week, 104(24):38, June 14, 1969.

15. Darnay, A. and W. E. Franklin (Midwest Research Institute). Role of Packaging in Solid Waste Management 1966 to 1976. USDHEW, PHS, BSWM, 1969.

16. Safe Use of Pesticides. American Public Health Association, Inc., New York, New York, 1967.

17. Safe Use of Agricultural and Household Pesticides. USDA Agriculture Handbook No. 321. Washington, D. C., January 1967.

18. Poisoning and Agricultural Workers. Pharm. J., 201, 547, 1968.

19. The Regulation of Pesticides in the U.S. USDA, DHEW (FDA), March 1968.

20. Wadleigh, C. H. Wastes in Relation to Agriculture and Forestry. USDA, Misc. Publ. No. 1065.

21. Safe Disposal of Empty Pesticide Containers and Surplus Pesticides. Agricultural Research Service, USDA, August 1964.

22. Stojanovic, B. (National Agricultural Chemicals Association, 1155 15th St., N.W., Washington, D. C. 20005). Pesticide Disposal. N.A.C. News Pest. Rev., 27(1), 13, 1968.

23. Rima, D. R., E. Brown, D. F. Goerlitz, and L. M. Law. Potential Contamination of the Hydrologic Environment from the Pesticide Waste Dump in Hardeman County, Tennessee. Water Resources Division, USGS ,Administrative Report to FWPCA, August 1967.

24. Editorial: The Pollution Loophole. Industrial Research, 11(5):9, May 1969.

25. Anonymous. If a Deep-Well Fails, Has the Concept Failed, Too? Industrial Research 11(8):13, August 1969.

26. Anonymous. Can we Continue to Sweep Pollution Under the Rug? Industrial Research 11(3):33, March 1969.

27. Anonymous. Deep Wells are Catching on as a Way of Disposing of Chemical Wastes. Chemical Week, 105(5):40, August 2, 1969.

28. Anonymous. A Catalyst to Cause DDT to Destroy Itself. Chemical Week, 105(3):31, July 19, 1969.

VII. APPENDIX

Excerpts from NACA Manual for Decontamination and Disposal of Empty Pesticide Containers (1965)[4]

1. Combustible Containers (in order of preference)
   a. Burn the empty containers in a commercial incinerator as soon as possible after they have been emptied.
   b. Burn the empty containers in a supervised public or private dump. Notify the supervisor of the nature of the containers so that necessary precautions may be taken.
   c. Burn the empty containers in an open fire at the site of use if such is permitted by local authorities.
   d. If unable to burn empty containers in any manner, thoroughly crush them and bury the pieces at least 18 inches deep in an isolated area away from water supplies.

   NOTE: Some weed killers when burned emit vapors which may cause damage to nearby crops. Containers of these products should not be burned but should be disposed of by the alternate methods recommended. Manufacturers of weed killers should be consulted for specific instructions regarding disposal of their products and/or containers by burning.

2. Small Non-Combustible Containers.

   It is strongly recommended that this type of empty container not be re-used for any purpose. However, it is also recognized that the five-gallon size metal container may have an economic value as a container for certain non-food materials and, in such cases, a specific decontamination procedure is recommended and included in this section.

The following procedure for decontaminating and disposing of empty non-combustible containers up to and including the five-gallon size is recommended. Each step must be followed in order to ensure safety in the disposal of the container. It is essential that all personnel engaged in the handling and decontamination of empty containers be aware of the potential hazards associated with the process. These hazards may be considered as those due to both contact with the residue in the container and/or contact with the corrosive action of the rinse solution. Personnel engaged in the decontamination process should wear protective clothing. Protective clothing should include appropriate gloves and footwear, freshly-laundered cap and coveralls, and goggles or face-shield.

a. Carefully and completely wash the outside of the empty container with water. Rinse out the inside of the container with water, to which has been added household or commercial detergent and caustic soda (lye).

b. Carefully discard the rinse solution by burying at least 18 inches deep in an isolated area away from water supplies.

c. Break glass containers completely, mutilate and puncture plastic containers, puncture and crush empty metal containers.

d. Discard all the pieces where they will be buried in a <u>supervised</u> public or private dump, and notify the supervisor of the nature of the material. If this is not feasible, bury all the pieces at least 18 inches deep in an isolated area away from water supplies.

3. Large Non-Combustible Containers

The following procedures for disposing of large, empty non-combustible containers are recommended. The procedures are recommended in the order of preference, with the first procedure being the most desirable. Before following any procedure, however, carefully and completely wash the outside of the container with water and decontaminate the inside of the container as recommended. It is essential that all personnel engaged in the handling and decontamination of empty containers be aware of the potential hazards associated with the process. These hazards may be considered as those due to both contact with the residue in the container and/or contact with the corrosive action of the rinse solution. Personnel engaged in the decontamination process should wear protective clothing. Protective clothing should include appropriate gloves and footwear, freshly-laundered cap and coveralls, and goggles or face-shield.

a. Tighten all bungs and closures, then transport or otherwise arrange for transportation to an assembly point previously designated by professional drum reconditioner for his eventual pick-up. The containers will then be professionally reconditioned following approved methods which will make the drum suitable for use as a container for non-food products.

b. After decontamination, drums may be used for transporting other non-food products which would react chemically to degrade the pesticide residues that may remain in the drum. (For example: lime-sulphur solution in phosphate ester pesticide drums).

c. Mutilate the container by puncturing or other means to prevent re-use. Either burn in a supervised public or private dump, notifying the supervisor of the nature of the material or, if this is not feasible, bury at least 18 inches deep in an isolated area away from water supplies.

d. After decontamination, mutilate decontaminated drums by puncturing or other means for disposal as scrap metal.

NOTE: In all of the above cases avoid contact with skin or breathing of dust or vapors. Stay well away from smoke or fumes when burning. Wash thoroughly with soap and water before eating or smoking and always at the end of the workday.